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Pharmacy Students' Attitudes Towards AI in Pharmaceutical Practices

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Abstract **Background:** The integration of Artificial Intelligence (AI) into healthcare systems has introduced substantial advancements in clinical and pharmaceutical practices. As future healthcare providers, pharmacy students are expected to engage with AI-enabled tools; however, limited empirical data are available on their familiarity with and attitudes toward, AI technologies. **Objective:** This study aimed to assess pharmacy students' knowledge of AI, their perceptions of its application in pharmaceutical settings and their intentions to incorporate AI into future practice. **Methods:** A cross-sectional descriptive study was conducted among 501 undergraduate pharmacy students in Saudi Arabia. Data were collected through a structured, self-administered online questionnaire consisting of demographic variables, AI familiarity, attitudinal measures and future intentions. Descriptive statistics and chi-square (χ^2) tests were used to examine associations between demographic characteristics and AI-related attitudes. **Results:** Of the 501 respondents, 48.61% reported moderate familiarity with AI, with online resources cited as the predominant source of knowledge (75.70%). Approximately 50.6% agreed that AI could reduce medication errors, while 54.98% affirmed that pharmacists would continue to play a critical role despite technological advancements. A total of 62.95% indicated a likelihood of using AI in their future practice. Statistically significant associations were identified between gender, academic year and both AI familiarity and willingness to adopt AI ($p<0.001$). **Conclusion:** The findings suggest a generally positive orientation among pharmacy students toward AI in pharmaceutical practice, alongside notable concerns regarding data privacy, job security and ethical implications. These results underscore the need for structured AI education within pharmacy curricula to enhance digital readiness and support responsible integration of AI technologies in future pharmaceutical services.

Key Words Artificial Intelligence, Pharmacy Education, Student Perceptions, Digital Health, Curriculum Integration, Saudi Arabia

INTRODUCTION

Artificial Intelligence (AI) is increasingly recognized as a transformative force in global healthcare delivery, offering substantial potential to improve quality of care, reduce clinical errors and enhance decision-making processes [1]. In the context of pharmaceutical practice, AI has been applied to diverse functions, including algorithm-driven drug discovery, automated medication adherence systems and clinical decision support tools for prescribing and dispensing medications [2,3]. These technological advancements are designed to augment pharmacy services by streamlining routine operations and increasing the accuracy of medication-related tasks [4].

Pharmacists, as integral members of the healthcare workforce, are now expected to work alongside intelligent systems that can enhance operational efficiency and support

individualized care. AI-enabled platforms have the capacity to minimize medication errors and allow pharmacists to shift focus toward more patient-centered and clinically complex responsibilities [5,6]. Nonetheless, several ethical and practical concerns persist, particularly in relation to data privacy, algorithmic accountability and the potential risk of job displacement within the profession [7].

The successful integration of AI into pharmacy practice largely depends on the knowledge, attitudes and preparedness of future pharmacists. Existing literature suggests that the perceptions of healthcare students play a significant role in shaping their acceptance and use of emerging technologies [8]. However, despite the expanding use of AI in healthcare systems, there is a notable lack of empirical studies that investigate pharmacy students' familiarity with AI, their primary sources of information and their expectations regarding the implications of AI for professional practice [9,10].

Addressing this research gap, the present study aims to systematically examine pharmacy students' attitudes toward AI in pharmaceutical contexts. The study focuses on assessing their demographic profiles, familiarity with AI technologies, perceived benefits and risks associated with AI adoption and their intentions to utilize such technologies in future practice. The findings are intended to inform educational policy and curricular development, ensuring that future pharmacists are adequately prepared to engage with AI-enabled healthcare environments in a responsible and competent manner.

METHODS

Study Design

This study adopted a cross-sectional descriptive survey design to explore pharmacy students' attitudes toward Artificial Intelligence (AI) in pharmaceutical practices. This design was considered appropriate for collecting data from a large sample at a single point in time and for identifying patterns in awareness, perceptions and behavioral intentions.

Participants and Sampling

The participants comprised 501 undergraduate pharmacy students across all years of study, including those in the internship phase. A convenience sampling method was employed to recruit participants due to logistical and access-related considerations. The inclusion criteria were:

- Enrollment in a pharmacy program
- Willingness to participate voluntarily
- Ability to complete the online questionnaire

Instrumentation

Data were collected using a structured, self-administered online questionnaire designed specifically for this study. The instrument was developed in English and consisted of four main sections:

- Demographic Characteristics: Age, gender, academic level and prior exposure to AI-related training
- Knowledge and Familiarity with AI: Assessed using a combination of closed-ended questions and rating scales
- Attitudes Toward AI: Measured via a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree"
- Future Intentions and Concerns: Included both categorical options and multiple-response items

The questionnaire was piloted among 25 pharmacy students to evaluate clarity, validity and reliability. Based on the feedback, minor modifications were implemented to improve comprehension. Internal consistency was verified, yielding a Cronbach's alpha coefficient of 0.82, indicating acceptable reliability.

Data Collection Procedure

The data collection was conducted over a six-week period using an online platform (Google Forms). The link to the questionnaire was disseminated through institutional mailing lists and social media platforms (WhatsApp and Telegram). Prior to participation, students were informed about the aim of the research and electronic informed consent was obtained. Participation was voluntary and anonymous, with confidentiality assured.

Ethical Considerations

Ethical approval was granted by the corresponding university's Institutional Review Board (IRB). All procedures adhered to ethical standards for research involving human participants. Students were assured that no personal identifiers would be recorded and that they had the right to withdraw at any stage without penalty.

Data Analysis

The collected data were exported and analyzed using IBM SPSS Statistics version 26. Descriptive statistics were generated, including frequencies, percentages, means and standard deviations. Cross-tabulations were used to explore distributions across demographic subgroups.

To determine associations between key variables (e.g., gender, year of study, familiarity with AI), Chi-square (χ^2) tests of independence were performed. Significance was set at $p<0.05$. This approach enabled a robust examination of the influence of demographic and educational factors on students' knowledge and attitudes toward AI.

Demographic Information

The survey results indicate that the majority of respondents (47.01%, N = 236) are between 21-23 years old, while 22.71% (N = 114) are aged 18-20. A smaller proportion falls into the 24-26 age group (17.33%, N = 87) and 12.55% (N = 63) are over 26 years old (Table 1). Regarding gender distribution, 67.53% (N = 339) of respondents are female, whereas 32.27% (N = 162) are male.

Most participants are either in their 4th year (25.3%, N = 127) or in the Internship phase (23.71%, N = 119). The 5th year accounts for 18.33% (N = 92), the 2nd year for 14.54% (N = 73), the 3rd year for 12.35% (N = 62) and the

Table 1: Demographic Characteristics

Question	Response Options	Frequency (N)	Percentage
Age	21-23	236	47.01%
	18-20	114	22.71%
	24-26	87	17.33%
	Over 26	63	12.55%
	Under 18	1	0.20%
Gender	Female	339	67.53%
	Male	162	32.27%
Year of Study	4th year	127	25.30%
	Internship	119	23.71%
	5th year	92	18.33%
	2nd year	73	14.54%
	3rd year	62	12.35%
	1st year	28	5.58%
Attended AI Course/Workshop	No	323	64.34%
	Yes	178	35.46%

Table 2: Familiarity with AI and Sources of Learning

Category	Response Options	Frequency (N)	Percentage
AI Familiarity Level	Moderately familiar	244	48.61%
	Slightly familiar	175	34.86%
	Very familiar	56	11.16%
	Not familiar at all	26	5.18%
Primary Source of AI Knowledge	Online resources (websites, videos)	380	75.70%
	University courses	52	10.36%
	Conferences/workshops	48	9.56%
	Other (self-learning, discussions, hands-on experience)	2	0.40%

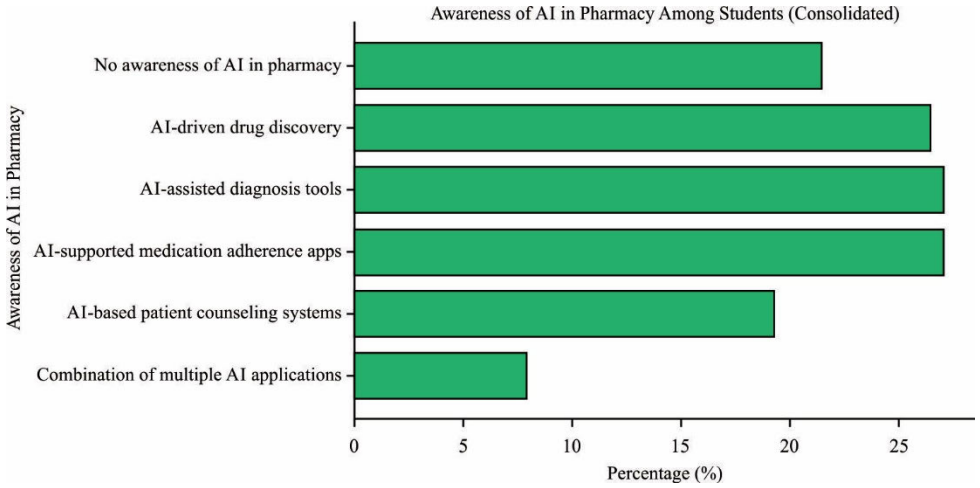

Figure 1: Awareness of AI in Pharmacy

1st year for 5.58% (N = 28). In terms of prior AI education, 64.34% (N = 323) have not attended any AI-related course or workshop, whereas 35.46% (N = 178) have participated in AI learning programs.

Demographic Information

Knowledge & Familiarity with AI: The results demonstrate that nearly half of the respondents (48.61%, N = 244) consider themselves moderately familiar with AI, while 34.86% (N = 175) reported slight familiarity. A smaller proportion (11.16%, N = 56) described themselves as very familiar and 5.18% (N = 26) stated they were not familiar with AI at all (Table 2).

Regarding sources of AI knowledge, 75.70% (N = 380) of students rely on online resources, such as websites and videos, while only 10.36% (N = 52) have learned about AI through university courses. Additionally, 9.56% (N = 48) have gained knowledge from conferences and workshops, whereas 0.40% (N = 2) have acquired AI knowledge through self-learning, discussions or hands-on experiences.

Knowledge & Familiarity with AI

Furthermore, awareness of AI applications in pharmacy varied significantly. As shown in (Figure 1), the most recognized applications included AI-driven drug discovery, AI-assisted diagnosis tools and AI-supported medication adherence apps.

Attitudes Toward AI in Pharmaceutical Practices

Regarding AI's role in improving dispensing accuracy, 47.61% (N = 239) agreed or strongly agreed that AI can significantly enhance accuracy in dispensing and

Table 3: Perceptions of AI in Pharmacy

Question	Response Options	Frequency (N)	Percentage
AI Improves Dispensing Accuracy	Strongly Disagree	48	9.56%
	Disagree	52	10.36%
	Neutral	162	32.27%
	Agree	149	29.68%
	Strongly Agree	90	17.93%
AI Reduces Medication Errors	Strongly Disagree	51	10.16%
	Disagree	49	9.76%
	Neutral	147	29.28%
	Agree	160	31.87%
	Strongly Agree	94	18.73%
Pharmacists Should Be Cautious About AI	Strongly Disagree	66	13.15%
	Disagree	65	12.95%
	Neutral	104	20.72%
	Agree	125	24.90%
	Strongly Agree	141	28.09%
Pharmacists Will Still Play a Critical Role	Strongly Disagree	59	11.75%
	Disagree	29	5.78%
	Neutral	70	13.94%
	Agree	67	13.35%
	Strongly Agree	276	54.98%

Table 4: Future AI Adoption and Concerns

Question	Response Options	Frequency (N)	Percentage
Likelihood of Using AI in Future Practice	Very Unlikely	24	4.78%
	Unlikely	19	3.78%
	Neutral	142	28.29%
	Likely	211	42.03%
	Very Likely	105	20.92%
Concerns About AI in Pharmacy	Job displacement	58	11.55%
	Data security & privacy	49	9.76%
	Reliability of AI software	40	7.97%
	Ethical concerns	14	2.79%
	High cost of implementation	12	2.39%
Recommend More AI Training in Pharmacy Schools	Definitely Not	34	6.77%
	Probably Not	24	4.78%
	Unsure	103	20.52%
	Probably Yes	213	42.43%
	Definitely Yes	127	25.30%

prescription verification. However, 19.92% (N = 100) expressed disagreement or strong disagreement, while 32.27% (N = 162) remained neutral, indicating a level of uncertainty about the effectiveness of AI in this area (Table 3).

In terms of AI's impact on reducing medication errors, 50.6% (N = 254) of respondents agreed or strongly agreed that AI could help mitigate medication errors. However, 19.92% (N = 100) disagreed and 29.28% (N = 147) were neutral, suggesting that while there is optimism about AI's potential, some students are hesitant about its reliability.

Concerns about AI adoption in pharmacy were also evident. 28.09% (N = 141) strongly agreed that pharmacists should be cautious when adopting AI tools due to potential issues related to data privacy and ethics. Additionally, 24.90% (N = 125) agreed, while 20.72% (N = 104) remained neutral, highlighting that ethical and regulatory considerations are significant concerns for many students.

Despite advancements in AI, students largely believe in the continued importance of pharmacists in patient care. 54.98% (N = 276) strongly agreed that pharmacists will continue to play a critical role despite AI's growing influence, while 17.53% (N = 88) expressed disagreement or strong disagreement and 13.94% (N = 70) remained neutral.

Attitudes Toward AI in Pharmaceutical Practices

Future Intentions & Concerns: The survey results indicate that a majority of respondents (42.03%, N = 211) are likely to use AI tools in their future pharmacy practice, with an additional 20.92% (N = 105) being very likely to do so. However, 4.78% (N = 24) stated they were very unlikely and 3.78% (N = 19) were unlikely to incorporate AI into their careers (Table 4). These findings suggest that while AI adoption in pharmacy is generally viewed positively, a subset of students remains hesitant about its integration.

When asked about concerns regarding AI implementation, the most commonly cited issues included job displacement (11.55%, N = 58), data security and patient privacy (9.76%, N = 49) and the reliability of AI software (7.97%, N = 40). Additionally, ethical concerns (2.79%, N = 14) and the high cost of AI implementation (2.39%, N = 12) were highlighted as potential barriers to AI adoption in pharmacy practice.

Table 5: Chi-Square Test Results

Variable 1	Variable 2	Chi2 Statistic	p-value	Degrees of Freedom (df)
AI Familiarity Level	Gender	505.04	<0.001	8
AI Familiarity Level	Year of Study	519.73	<0.001	24
Likelihood of Using AI in Future Practice	Gender	508.36	<0.001	10
Likelihood of Using AI in Future Practice	Year of Study	554.91	<0.001	30
Attended AI Course/Workshop	Gender	503.72	<0.001	4

Regarding AI training in pharmacy programs, 42.43% (N = 213) of respondents supported increasing AI-related education, with 25.30% (N = 127) strongly advocating for its inclusion. However, 20.52% (N = 103) remained unsure and 11.55% (N = 58) opposed the integration of additional AI training in pharmacy curricula. These findings emphasize the need for structured AI education to address students' concerns and ensure they are well-prepared to work with AI-driven healthcare technologies.

Future Intentions & Concerns

The results indicate that AI Familiarity Level is significantly associated with both Gender ($p<0.001$) and Year of Study ($p<0.001$), suggesting that familiarity with AI varies across different demographic groups (Table 5). Additionally, Likelihood of Using AI in Future Practice is significantly influenced by Gender ($p<0.001$) and Year of Study ($p<0.001$), highlighting that demographic factors impact students' willingness to adopt AI in their professional careers. Furthermore, participation in AI-related courses or workshops is significantly associated with Gender ($p<0.001$), indicating potential differences in AI training engagement between male and female students.

This study aimed to examine pharmacy students' familiarity with Artificial Intelligence (AI), their perceptions of its applications in pharmaceutical practice and their intentions regarding future use. The findings indicate a generally positive orientation toward AI, with approximately half of the participants reporting moderate familiarity and a majority expressing support for the integration of AI into pharmacy education. Nevertheless, the presence of ethical concerns and cautious attitudes toward AI adoption was also apparent.

These findings are consistent with earlier research emphasizing the increasing relevance of AI in healthcare and the corresponding imperative for educational preparedness and regulatory alignment [1-3]. The results also align with recent work by Alhur, which documented both moderate public awareness and notable apprehension concerning the use of AI in personalized pharmacotherapy [11].

A significant observation in this study is that most students acquire AI-related knowledge through informal sources-particularly online platforms-while only a small minority reported learning through formal academic coursework. Specifically, 75.70% of respondents identified digital resources as their primary source of AI information, whereas just 10.36% cited university courses. These figures are consistent with previous surveys and curricular analyses by Alhur, which revealed limited formal integration of AI content within pharmacy and medical programs in Saudi Arabia [12,13]. This suggests a substantial educational gap that warrants targeted curricular reform to equip future pharmacists with both theoretical understanding and applied competencies in AI.

Regarding perceptions of AI's utility, over half of the participants agreed that AI has the potential to enhance dispensing accuracy and reduce medication errors-findings that are congruent with established literature on AI's role in supporting clinical decision-making and improving medication safety [4,5]. Moreover, a majority of students expressed the belief that pharmacists will retain a critical role within AI-enabled systems, reinforcing the conceptualization of AI as an augmentative rather than substitutive tool [6].

Despite these positive perceptions, ethical and practical concerns were also prominent. Approximately one-fifth of respondents expressed reservations about AI, particularly in relation to data privacy, decision accountability and the risk of professional displacement. These concerns echo those reported in broader public discourse, where trust in software reliability and the safeguarding of sensitive health information remain significant barriers to AI acceptance [12-16].

Notably, 62.95% of students reported being likely or very likely to adopt AI tools in their future practice. This forward-looking intent was accompanied by considerable support for the inclusion of AI training in the pharmacy curriculum, with 42.43% of respondents expressing probable support and 25.30% indicating strong support. These results lend support to ongoing calls for the integration of digital health competencies within pharmacy education frameworks [17].

Chi-square analyses revealed statistically significant associations between gender and academic year with both AI familiarity and intent to adopt AI in future practice ($p<0.001$). These findings suggest that academic exposure and student characteristics may influence perceptions of emerging technologies and they highlight the need for further investigation through longitudinal or cohort-based designs.

While this study contributes meaningful insights, several limitations should be acknowledged. The use of convenience sampling may have introduced selection bias, thereby limiting the generalizability of the findings. In addition, the self-reported nature of the data raises the possibility of social desirability bias. Finally, the cross-sectional design restricts the ability to evaluate temporal changes in students' perceptions or behaviors.

Despite these limitations, the study offers one of the few empirical assessments of pharmacy students' views on AI in the context of Saudi Arabia. It adds to the limited but growing body of literature on digital health literacy among healthcare students in the region.

CONCLUSIONS

This study has shown that pharmacy students possess a moderate level of familiarity with AI and generally hold positive attitudes toward its integration into pharmaceutical practice. While many recognize AI's potential to enhance accuracy and efficiency, concerns remain about ethics, privacy and job security. The findings underscore the importance of embedding structured AI education into pharmacy curricula to prepare future professionals for a digitally enabled healthcare environment. Further research is needed to evaluate the effectiveness of such educational initiatives and to explore faculty and institutional readiness for AI integration.

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